Gaiashield Group

The Sky Is Falling... Now!

Strategic and Tactical Comments On:
"Goals and Objectives for the Exploration and Investigation of the Solar System's Small Bodies"
<http://www.lpi.usra.edu/sbag/goals/GoalsDoc_ver.1.1.2016.pdf>

Goal 2 – Defend Planet Earth:
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19 *Goal 2. Defend Planet Earth*

SBAG Goal 2. Defend Planet Earth

Understand the population of small bodies that may impact our planet and develop ways to defend the Earth against any potential hazards.

If such an airburst were to happen over a major population center, significant loss of life might result.

Perhaps *some* loss of life... This is just B612/Sentinel fund raising hyperbole: fear mongering.

and impacts from larger objects are infrequent, as asteroids larger than 30 meters in diameter are estimated to strike the Earth only roughly once every few centuries, and those larger than 300 meters in diameter only once per hundred thousand years, on average *11* <footnote>*: 11(It is important to recognize that Earth impact frequency statistics are very approximate and represent long-term averages at best. Earth impacts by NEOs are, in general, aperiodic events that can occur at any time.)*.

The footnote qualifier is at least leaning in the right direction. However, for the reader it generates a cognitive dissonance which is usually resolved by choosing the information they like best. In this case it would be frequency and some degree of predictable and expectable periodicity. No one likes things to happen at Random unless they are in Vegas. The problem here is that an averaged relative frequency of randomly occurring events is imaginary and either a product of corrupted empirical information or an incomplete rational understanding of the geometry and dynamics of the condition. Why offer it at all? You are scientists! You can't just make stuff up and call it information. Science is not Art.

Asteroid impact events are completely Random: without any recursive pattern, both in their occasion and magnitude. We don't know when the next 10m or 100m or 1,000m or 10,000m asteroid will strike... period. And Hope and Optimism and Good Luck aside, since our ignorance and uncertainty for any of the above is absolute, our rational expectations for any class of asteroid impact event should be equal.

How many 300m or 10,000m asteroid impact events are likely to occur at Random over the next billion years in the life of Earth may be scientifically interesting. But since the topic here is Planetary Defense, this general Random Frequency is strategically irrelevant. Completely useless as predictive information to help shape and inform any rational decision making process. In terms of our response, the tactically relevant questions are how large is the *next* asteroid on its way to strike earth and when will it strike? Which can only be answered by knowing which asteroid is the next asteroid on its way to strike Earth. Unfortunately, strategically: what is essential to the conduct of implementing our response, we can never know when we are going to know which, when and how large until it is... *Now*!

In short: "*aperiodic events that can occur at any time*" includes the equal prospect for extinction level impact events... at any time. Therefore, given the scale of the response required for this worst case scenario, vigilance alone is not enough. We must become prepared and trained to successfully respond to this level of this threat before we see it coming. And before we see it coming begins... *Now*! It only takes one rock to kill us all.

planetary defense can be divided into five main categories: 1) finding the potentially hazardous asteroids and comets; 2) characterizing them; 3) assessing the potential risk to Earth; 4) mitigation through deflection and/or disruption; and 5) coordination, civil defense, and emergency response to such a threat.

In order to develop what is essential to the conduct of successfully implementing any response and enabling the execution of these tactical objectives, we first think strategically:

1) Develop a respondable definition of the threat - Since there is no imaginable way we can respond to the existential systemic condition, (change the laws of physics or beam all these objects to a Galaxy far, far away) the best tactical definition becomes the only strategic definition: The Next Large Asteroid on its way to strike Earth.

2) Formal expression of Political Will: As a Global precedent, codify a National Policy to endeavor to deflect these objects as they present themselves to be impending Earth impact threats (legally justifying and enabling funding).

3) Responsibility: As a Global precedent, delegate or create a qualified National Planetary Defense Agency to become suitably vigilant and prepared and expert in executing our Political Will and the object of the legally justified funding.

4) First agency responsibility: Develop a comprehensive Strategy in Principles. This would include the selection and development of the single most effective means to respond to any level of this threat in terms of Preparation, Training and Vigilance.

Then simultaneously, Tactically:

1) Begin to determine which asteroid will be the next asteroid on its way to strike Earth.

2) Develop and build an effective means to respond to this threat in its worst case manifestation.

3) Become expert in deflecting these objects - Practice/Practice/Practice.

4) Execute our Political Will as needed.

The notion of ignoring intensive training; and waiting until we see it coming before we develop, build and deploy a means to deflect these objects; and the need for a space based Strategic Surveillance network in order to reliably see them coming early enough to effectively respond... is nothing more than a formula for our random, sooner-or-later, suicide by asteroid impact. And since this threat will never go away, whatever we decide we need to do today we will need to do Forever.

Objective 2.1. Identify and track potentially hazardous objects.

2.1.1. Maintain and improve ground- and space-based surveying capabilities.

The discovery and tracking of the near-Earth object (NEO) population is the first step in a viable planetary defense strategy. An object's orbit defines if, when, and how an impact will occur, and is key in defining warning times and deflection requirements.

The proximate cause for all asteroid impact events would be some random and dramatic kinetic or gravitational perturbation. The proximity of the orbits of these objects to Earth's orbit is irrelevant. What is relevant is the opportunity and potential for these objects to become perturbed. And it's like a Pachinko machine out there. Which makes any asteroid in the Solar System a candidate for the next asteroid on its way to strike Earth. This dynamic extends to Kuiper Belt and Oort Cloud objects as well.

Therefore, what we are doing now, and currently intend to do in the future, is next to useless. Nothing more than counting rocks in Space. a) It assumes the next asteroid on its way to strike Earth will be a NEO. b) It assumes it will have already been perturbed into an impact trajectory before we discover it. c) It assumes that it will not become perturbed into an impact trajectory after we determine its orbital elements, find it 'safe' and move on to find another. In fact, a NEO we have discovered and found to be safe is no less likely to become a near-term impact threat than any undiscovered asteroid... NEO or not.

Not only is this gambling, it is bad gambling... or Cosmic level Observational Bias: 'the light is better for NEOs so let's look for our problems there'. Maybe we'll get lucky?

What is required is that we evolve this Scientific Survey into Strategic Surveillance. Ideally, a network of Space based telescopes covering a dedicated Area of Interest with a full spectrum, Real Time observation of this area 24/7/52... Forever. A picket line/trip wire Early Warning System that can tell us when anything out there is now moving in our direction. Remember, it only takes one rock to kill us all.

Congress has given NASA two directions addressing NEO detection. The first, known as the Spaceguard Survey, was to detect 90% of NEOs larger than 1 km in diameter <SNIP> The second, known as the George E. Brown... 90% of all NEOs larger than 140 m in diameter

It can not be taken that success in achieving these Congressional directives could in any way constitute a commensurate reduction in the near-term 100 year risk of 1 NEO impact from these populations. If the condition is such that we estimate there to be 1,000 large NEOs and hold that the perceived possible 100 year risk to be that of 1 large NEO impact... then whether there is in fact 1 large NEO on its way to strike Earth in the next 100 years or there is no large NEO on its way to strike Earth in the next 100 years, with an empirical Survey, in either case we would expect to find 999 large NEOs not to be on their way to strike Earth.

Therefore, if we do find 999 large NEOs to not be on a collision course with Earth (finding what we would expect to find), then the initial condition has not changed and therefore we can have no reason to change our perception and the possibility of 1 large NEO impact in the next 100 years stands unmitigated. So, show me the last large NEO! However, such a survey would reduce the perceived possible risk of 1,000 large NEOs striking Earth in the next 100 years... rock by rock.

But absence of evidence is not evidence of absence.

Then, given we are only working from some power law estimate, we can never be certain of the actual number of large NEOs or therefore in finding the last large NEO. And/or unless we have the entire discovered population under 24/7/52 Real Time surveillance, know that previously considered 'safe' large NEOs have not become perturbed into impending impact threats. And/or know that some large asteroid has not been newly perturbed from the Main Belt onto a direct collision course with Earth.

Since we should understand rationally that The Next Large Asteroid on its way to strike Earth is an existential reality, then the only way to actually reduce the risk of asteroid impact through observation, the only metric for success, would be to determine which asteroid is The Next Large Asteroid on its way to strike Earth in order to deflect it... and ASAFP.

However, it is clear that current survey systems will not be able to reach the George E. Brown goal by 2020 or even within the next decade from now. Several study reports (Stokes et al. 2003; *National Research Council, 2010) have found that a space mission conducted in concert with observations from a suitable ground-based telescope would be the best approach.*

This may have been true in 2010 when NEO-OP first took over from the Spaceguard Survey with its puny $4m/yr budget. However, after some impressive scrounging in the hallways of NASA, NEO-OP has managed to increase its budget to $50m/yr. And, all things considered, should complete Brown reasonably close to the 2020 deadline. Well before any Sentinel or NEOCam mission could even get off the launch pad. If not, the astronomers can always tweak the NEO population estimate to match their results... again. Then they can declare victory, turn off the telescopes, and go home... World Saved!

While the George E. Brown goal is focused on 140-m and larger objects, smaller objects also present hazards, as demonstrated by the Tunguska (~30 m) and Chelyabinsk (~20 m) airbursts.

Which would require an Act of Congress to address. But after 25 years they have likely had their fill of Scientific Surveys. So perhaps if this were presented as a Clear and Present Danger and a threat to National Security requiring an evolution to Strategic Surveillance. Like the ATLAS Program writ large.

Identifying all objects that pose threats to Earth is a fundamental objective of long-term planetary defense strategies that is accomplished by continually maintaining and improving survey capabilities.

Since some random dramatic perturbation is the proximate cause of asteroid impact events, then any asteroid in the Solar System of any size can be perturbed into an Earth-orbit crossing orbit or direct impact trajectory at any time. Therefore every asteroid in the Solar System: discovered/undiscovered, ECA, PHA, NEO, NMO, Main Belt or Trojan, poses a threat to Earth. There simply is no such thing as a 'safe' asteroid. Reliably identifying impending impact threats will require some form of Real Time Surveillance of some reasonable 41,253 square degree Area of Interest. Perhaps to the orbit of Mars. And maintaining and improving *this* strategic capability... Forever.

2.1.2. Identify imminent impactors, to enable wide-ranging characterization of the bodies prior to and after impact.

There have so far been two very small Earth impacts by asteroids discovered prior to atmospheric entry <SNIP> *Such events provide an opportunity to gain unique knowledge about the quantitative threats posed by impactors, with characterization while the object is still in space, during atmospheric passage, and finally in the laboratory*

You can not observe one asteroid and reliably extrapolate anything tactically useful about another asteroid. Asteroids are far to unique and discrete in their characteristics for any such general assessment. You can only reliably assess the characteristics of the asteroid you are observing.

Therefore, tactically, there are no reliable quantitative characteristics that can be assumed that would help with deflecting the next asteroid on its way to strike Earth. Which is not really a problem with Nukes. Then, the only thing we need are the asteroid's speed, direction and position relative to Earth... mass would be nice if we have the time.

Objective 2.2. Characterize the properties of near-Earth objects to advance both our understanding of the threats posed to our planet and how Earth impacts may be prevented in the future.

While an object's orbit determines if, when, and where an impact will occur, its physical characteristics play a crucial role in the potential damage it could do and in how the object would be effected by a mitigation mission.

'The potential damage it could do' is only relevant if our Planetary Defense efforts fail and then it is not as if we won't get way out of Dodge if it's only made of stone and not iron ore. FEMA will have to assess and deal with the ground truth of the impact after the fact no matter what it is made of.

And 'mitigate' means 'to reduce the severity of'. You can reduce the severity of the risk, you can reduce the severity of the threat and you can reduce the severity of the consequences of an impact. But you can not reduce the severity of an asteroid. The word here would be 'Deflect' or 'Divert' or 'Explode' (which would just be deflection in detail). Using 'mitigate' just serves to confuse the politicians and soldiers and lawyers and everyone else in The Real that you may want to influence and inform about this threat. Particularly those lawyer/politicians in Congress who control the money.

2.2.1. Determine the physical properties of the NEO population.

The NEO's mass is perhaps the most important physical characteristic to determine, but also one of the most difficult to measure. The object's mass combined with the warning time sets the deflection difficulty and is also a key parameter in determining the damage the object would inflict on Earth.

Unless we can come up with a way to assess an asteroid's actual mass other than its reflected light or ambient heat, this would require a precursor/reconnaissance mission. The problem with such a mission up front would be that whatever time we take for such a mission would be at the cost of the size of our back end post deflection Displacement Window. Which would result in increasing the size of the deflection effort. If the asteroid is small and the Detection-to-Impact Window is large and we have a good launch window and we have overcome our academic aversion to Nukes, such a mission might make sense. The option would be to afford the mass characteristic with a margin of error assuming the greater mass. When you consider building the precursor vehicle and rocket, waiting for a suitable Launch Window with an accompanying suitable Transit Time (both a matter of random-chance) and how long it might take to complete its assessments, such a mission might easily take 10 years. Just sending 2 Nukes instead of 1 might be the better solution. Time is not on our side here... Nukes are.

Several methods are currently used to estimate mass, but the uncertainty can be as large as an order of magnitude.

Make that 2 *big* Nukes then. This is not the time for rocket surgery.

porosity at some distance inside the object can dampen the shock produced by the kinetic impactor and thus limit damage to the object.

But not the momentum transfer. If we want to explode the asteroid, we want to deliver enough energy to break up the asteroid into small fragments and randomly disperse them beyond the escape velocity of the asteroid and far enough that few of them go on to strike Earth... sounds like a job for Nukes then.

The shape of the object is also an important factor that influences the effectiveness of a kinetic or nuclear deflection attempt.

Another problem better addressed by Nukes. Whereas a Kinetic Impactor approach requires the highest possible relative impact velocity, Nukes do not. We can rendezvous and orbit a nuclear device selecting the best point to detonate a standoff deflection or land a near or at surface detonation. Long term, we can even consider making such missions manned. Nothing like having a Human on this job.

2.2.2. Determine the chemical properties of the NEO population.

The composition of the object is another key parameter that plays a central role in how an asteroid reacts to a mitigation attempt using a kinetic impactor or nuclear device.

'*Deflection* attempt'... Let's face it. KI is a Goldilocks approach at its best. Everything has to be just right. Then, in terms of mission mass to work done, Nukes can be seen to be 10,000 times more effective (1,000 times if you think momentum enhancement is real and you are lucky and have a high impact velocity at the point of interception). So speaking for Nukes: we are not going to ad hoc custom design a Nuke around the possible composition of a given asteroid. We need to design a Space Capable Nuclear NEO Mine to give us the minimum mass and maximum yield. The First Law in mastering Space is Mass is Bad. The one Nuke fits any flavor rock approach.

Objective 2.3. Develop rigorous models to assess the risk to Earth from the wide-ranging potential impact conditions.

2.3.1. Understand the effects and potential damage from an atmospheric airburst or surface impact event.

Reliable prediction of the level of direct or indirect damage caused by a NEO via an airburst or surface impact on either land or water based is currently in need of development. This knowledge is a crucial consideration in formulating a proper response to possible impact threats.

Asteroid hits... After the fact you rescue, feed and house the survivors and bury the dead. How is this difficult. If FEMA makes any plans beyond that and shows them to the Gods they will piss their pants laughing. KISS: Big asteroid: all hands on deck. Little asteroid: ramp down as needed. However, we do need to refine our understanding of how the force is generated in an airburst. It seems to have been been grossly overstated. Think shocked acceleration and compare the velocity of a vaporized ton of stone to that of a ton of TNT then calculate the kilotons of TNT yield equivalence. What we have seen claimed is the same force in an asteroid airburst as the kinetic energy for the asteroid hitting ground. That can't be right...

2.3.2. Understand how the impact location may influence the damage evaluation, thus guiding mitigation and civil defense strategies.

A composite risk assessment map should be developed to fully evaluate how impact location could influence the damage evaluation, thus guiding mitigation strategies.

Here you may be using 'mitigation' correctly. It sounds like you want a map of locations you can divert an asteroid to that reduces the severity of harm on impact. How about anywhere *but* Earth? I'm sure, depending on who you ask, there are locations where an asteroid impact might do some good! Or are you just saying that such a map will help a FEMA prepare and 'reduce the severity of' the consequences of an impact event when a deflection attempt has failed? Let's save the confusion for the enemy.

Then, in terms of FEMA, as things stand it is far more likely that a deflection attempt will fail in the event of a *large* asteroid threat. Then, unless those disaster relief resources have been pulled back to Canada and Mexico or well secured underground before impact, they will likely be lost in the event. You may want to plan for that...

2.3.3. Develop risk assessment tools that are capable of near-real time risk and damage assessment to support decision makers in the event of an imminent impact threat.

provide a set of risk assessment tools to support and aid decision makers in the event that an impact threat is discovered.

Wouldn't those who craft the 'risk assessment tools' be the best qualified to make the decisions? (To live in a perfect world.) But then the best qualified would be Expert Risk Managers and Master Strategists and Executive Decision Makers: engineers of method. People who have dealt with Harm's Way on a daily basis professionally. And instead what we have is astronomers, astronauts, aerospace engineers and assorted academics...

Scientists objectively determine the difference between what is true and what is false then present the information without bias. Then based on what is true and what is false and relevant to a threat, Risk Managers et al subjectively determine the difference between what is wise and what is stupid then based on what is true and what is false and relevant to a response, take a biased course of action to achieve a specific desirable outcome. Although these are antithetical aptitudes and skill sets, in some form they are mutually constructive and necessarily so in successfully doing things. So far, this issue is effectively completely absent of Expert Risk Managers, Master Strategists and Executive Decision Makers. And as such, with no apparent guidance as to what is wise or what is stupid or what is relevant.

In building and managing a Planetary Defense scientists and engineers of technology have a critical role and responsibility here: find the dots. Connecting those dots effectively is a risk management, strategic thinking and decision making problem. A job for engineers of method. The need to recognize this and recruit such individuals into the PD community to ensure wisdom, guard against stupidity and irrelevance and that we get the best possible picture of what a Planetary Defense should be is critical.

Note: Risk Management is based in the art of applied rational pessimism. When you have to appeal to random-chance expect bad luck. Plan A will always fail... as will Plan B, so Plan C must include egress from the battlefield. Shit Always Happens. Murphy's Law rules. Optimism is anathema. Abandon all Hope... Then come up with the best solution to the problem. With an ethic and credo of 'Tempered only by capability and value, Leave Nothing To Chance', not everyone can comfortably wear this hat.

Although the Existential threat here can be seen as The Next Large Asteroid on it way to strike Earth, for the Strategic threat, what is essential to the conduct of implementing a response, the fearful and intractable aspect of the enemy in this war can be seen to be random-chance. Therefore, in our response the Planetary Defender, the engineer of this method, must endeavor to Leave Nothing To Chance. And given the potential magnitude of the loss: all there is, gone... Forever, at any cost and by any means necessary... Failure is Not an Option.

These tools should be able to provide near-real time updated information on the risk assessments (impact probability, expected impact corridor, expected range of damage, etc.)

You would provide tools requiring a fundamental understanding of probability ellipse and orbital mechanics and kinetic energy and shocked acceleration and the random-chance strategic and tactical variables in a Detection-to-Impact Window to a President Donald Trump or President Hillary Clinton and expect a right and timely response?

Plan B: 1) Create a National Planetary Defense Agency. Then: 2) give POTUS a big red button that says “In Case of Asteroid Press Here” authorizing the NPDA to act. Then 3) have someone at the NPDA responsible for charging into the Oval Office, arms waving hair-on-fire to tell POTUS when to push the red button. Or Plan C: We could let Congress handle it... <insert laugh track>. Remember, it only takes one rock to kill us all.

We are already in a state of war with Asteroids and Comets and Centaurs. They take no prisoners, show no mercy, allow no surrender or retreat. We are just not fighting back, yet. We need to formally declare this war and then establish Rules of Engagement where our National Planetary Defense Agency can automatically respond to a given threat without an explicit ad hoc Executive Order or Act of Congress.

Detection-to-Impact Window: A moderate optimal allowance and expectation... as things stand.
Stage 5 -10 years: Displacement Window (post any force imparting 1cm/sec DV 'nudge'.)
Stage 4 - 5 years: Transit Window (includes application of force for KI/NED)
Stage 3 - 5 years: Launch-Window Window (random optimal opportunity for a one rocket mission)
Stage 2 - 5 years: Construction Window (select, design, develop, build, test and train)
Stage 1 - 5 years: Political/Recon Window (precursor mission and optimistic political debate period)

So, an event that may or may not occur in 30 years... perfect opportunity for the politicians to employ their famous kick-the-can-down-the-road approach to decision making. We can not leave pulling the trigger on our response to the wisdom of our politicians.

Objective 2.4. Develop robust mitigation approaches to address potential impactor threats.

2.4.1. Ensure that potential threats are addressed by early mitigation planning for potential Earth impactors.

Current impact monitoring systems at JPL and the University of Pisa continuously scan the NEO orbit catalog for potential impacts within the next 100 years,

Which is not remotely the same as continuously scanning the asteroids themselves. These rocks have a tendency to not stay where we found them. Eros, the target of the NEAR mission was found to have over 100,000 impact craters on its surface. Every crater evidence of some change in its orbit. Just the fact that most NEOs were formed in the Main Belt and have become perturbed into rogue orbits tells us that these rocks can not be trusted to stay any longer than the second we take our eyes off them. And it only takes one rock to kill us all.

It is thus important to provide active monitoring of the Potential Impactor Risk List and development of quick assessments of mitigation timelines to ensure that potential threats are addressed with appropriate resources and in a timely manner.

Facilitated by a score of Space Based Observatories strategically deployed in heliocentric orbits at or around the orbits of Earth and Mars, it is important to monitor an Area of Interest and establish a zone of Early Warning surveillance in Real Time for any asteroid that has recently *become* perturbed from *any* asteroid population into being a potential Earth impact threat... Forever.

2.4.2. Develop and validate planetary defense approaches and missions.

A number of studies conducted over the past decade have found the following three proposed planetary defense systems to be the top candidates for such missions: Nuclear Explosive Device (NED), Kinetic Impactor (KI), and Gravity Tractor (GT).

In 2006 the NASA NEO Workshop came to conclusion that, in terms of mission mass to work, a NED standoff ablation approach in an off-the-shelf conservative application, compared to a KI approach in an optimized application, that the NED would be 100 times more effective than the KI. However, in an optimized NED application that margin would be 10,000 times. The GT was even less effective than the KI and summarily dismissed as being far from being a developed technology.

Further, the KI is limited to decelerating an object, useless against loosely bound rubble piles and requires a high relative impact velocity to work at all and as such carries a high risk of missing the target altogether. In short, everything for the KI has to be just right: a Goldilocks approach. Whereas the NED is far more robust and versatile. It can be employed in either deceleration or acceleration as may best serve the asteroid's probable trajectory, in a standoff approach for loosely bound rubble piles and either in a high speed flyby or gradual rendezvous affording more precise control and placement affording a far higher probability of not only hitting the target and hitting it where we want to.

We can make NEDs big or small. We can vary their yield on the fly. We can use one big one or multiple small ones to distribute the force. And they are the only realistic way to to explode or vaporize an asteroid... and they are 10,000 times more effective than the First Second Best Alternative! Since they easily ramp down in their effect to deal with smaller threats and are the only feasible approach we have to threats over a couple hundred meters, the NED is one tactic that fits all size threats. No strategist worth his salt would want anything else.

The only drawbacks to the NED approach are political. We are engineers of technology and method. Let's do what we do best: connect the dots and find the shortest distance between the problem and the solution. Let the Politicians handle the political problems. That's why they get the big money.

That said, from theoretical studies we can expect that to impart 1cm DV to a 10km asteroid would require 1,000 Mt of yield at the surface of the target. At 5 Mt yield per ton of device (B-41) requiring 40 Atlas V delivery systems. However, when we consider the margins of error we need to address at the point of execution: target mass, impact probability ellipse and technology failure, make that x10 or 400 Atlas V delivery systems. (Margins of Error Assessment. There's a multi million dollar research project for the rocketboys.) Then, 400 Atlas Vs... makes you wonder if we are going to have enough (or any) suitable Launch/Transit Windows for a mission of that scale. Not really the kind of thing we want to put off preparing for until after we see it coming... Perhaps we should preposition something like this to heliocentric orbit... say at Sun/Mars L3, L4, L5? (Another multi million dollar research project for the rocketboys!) If we prepare for the best and only Hope against the worst, how can we see that as wise?

A planetary defense flight validation mission would be necessary prior to a technique being considered operationally ready for the execution of an actual planetary defense mission that to deflect or disrupt a NEO with high reliability.

In terms of reliability, we need to select the best tactic and evolve not only the technology but human capabilities as well. We need to become expert at deflecting asteroids: Practice/Practice/Practice. Nuking an asteroid every 5 years or so... Forever. Target the Earth-orbit Crossing Asteroids. After all, if we appeal to the law of averages, inevitably, at random all ECAs will sooner-or-later strike Earth. So clean up the neighborhood. Explode them into rapidly expanding balls of space gas and debris or nudge them out to be only harmless NEOs. Then put the whole thing on Pay Per View.

2.4.3. Have the capability to respond rapidly with characterization or mitigation missions.

The need for a planetary-defense mission aimed at deflecting or disrupting an incoming NEO may possibly arise with relatively little warning.

At random, sooner-or-later, it is statistically certain... and that it will be large. Although it is certainly a scenario for recently perturbed large asteroids, Long Period Comets exemplify the threat best. Since their detection as impending impact threats will not be possible until they begin sublimating water ice at the orbit of Jupiter we may only have as little as 9 months to mount a response.

Enter the BFN Point Defense: A Big 'Fat' Nuke (25 Mt/B-41) predeployed to the ISS payloaded into a boosted Atlas V 3rd stage. Then shoot it in the face as it crosses the orbit of Mars. At 50 million miles even for large threats most of the exploded fragments will have enough DV to miss Earth entirely. For the largest of threats, we might make that a Teller Class 1 Gt Nuke payloaded on a boosted SLS 3rd stage. It depends: "Do you feel lucky... well do ya, punk?"

missions rapidly deployed to potentially hazardous NEOs to measure in situ their physical and chemical properties and structures can provide crucial information to inform decision makers.

Far easier and cheaper and more hopefully said, than done...

The first cost would be time. Even with a standing ready-to-launch mission, given the random-chance Launch/Transit Window availability, such a mission could still take as much as 10 years. We could buy some of that back by upgrading the typical small satellite launch vehicle from say an Atlas V to an SLS. But not completely. The strategic risk we incur with even the notion of a standing ready-to-launch precursor mission would be the 'opportunity' for the decision makers to put off pulling the trigger on building any deflection mission until they have the results of the precursor mission. Which begs the notion of a standing ready-to-launch deflection mission or the wisdom on the part of our decision makers to go forward in at least building the deflection mission with its launch and execution pending the results of the precursor mission. Time will never be on our side here. It may be faster, cheaper therefore better to at least address mass as a margin of error and increase the mission size accordingly.

Since the first characteristic we need to address is whether on not we are looking at an impending Earth impactor, we can dramatically improve our observational capabilities to resolve the uncertainty in any impact probability if we already have a Early Warning System of multiple Space Based Observatories by simultaneous triangulation of the object in question.

Then, for Nukes, given the object has been determined to be a threat, the second set of characteristics we would need to address would be the object's mass and structure. Together, these two factors could effect the magnitude of an effective mission by 20 times. The mass could be twice what we might assume to be average, increasing the mission by a factor of 2. And by its structure as either monolithic or a loosely bound rubble pile, determine the point of detonation. Potentially moving it from at or near surface to standoff at 1 radius decreasing the energy deposited by a factor of 10.

To determine an object's mass we need to either co orbit or orbit the object and test the gravitational force between them. To determine whether it is monolithic or loosely bound rubble pile... we need to thump it with a KI or small Nuke and closely observe what happens. AIDA looks like the right kind of mission for this precursor/recon role. But target Didymos not Didymoon. Didymoon will be a far more difficult target than any actual deflection or precursor/recon mission would ever be and as a demonstration of concept mission, has a very low probability of success. NASA's PA&E won't buy it.

missions have been sent to asteroids and comets, such missions generally require several years, usually five or six years, from mission concept development to launch.

However, in these missions we always had the luxury of selecting what specific asteroids or comets we would have a suitable Launch/Transit Window for. The next asteroid on its way to strike Earth will not afford us that luxury. The Detection-to-Impact Window will be determined by the asteroid and if or when there will be a suitable Launch/Transit Window will be a matter of random-chance.

Additionally, a planetary-defense mission aimed at deflecting or disrupting an incoming NEO, possibly with relatively little warning, would not be able to tolerate any failures or schedule slips.

From political will through infrastructure to execution, best addressed by Practice/Practice/Practice aka Drill/Drill/Drill: Preparation/Training/Vigilance. We need to be nuking an asteroid once every 5 years and become Experts at defending the planet from asteroid impact.

Ways to reduce response times when it is necessary to visit or deflect a potential impactor are needed, and having small scout-class missions ready to go in order to rapidly characterize objects

Launch/Transit Windows permitting. Unless 'ready to go' includes being predeployed to some heliocentric orbit like the orbit of Mars. Then, following the same logic, 'ready to go' should include the deflection aspect of our response and also predeployed to some heliocentric orbit like the orbit of Mars.

identify ways to reduce response time by compressing the development and launch schedules of reconnaissance and/or mitigation missions without compromising reliability.

Or selecting, building and predeploying the deflection aspect of our response to Sun/Mars L3, L4, L5. Remember, it only takes one rock to kill us all.

Objective 2.5. Establish coordination and civil defense strategies and procedures to enable emergency response and recovery actions.

2.5.1. Establishment of a Planetary Defense Coordination Office that will work on policy and responsibilities with respect to the threat posed by near-Earth objects.

A central Planetary Defense Coordination Office would enable efficient coordination of the policies and responsibilities for efforts related to threats posed by near-Earth objects. The 2010 NASA Advisory Council Planetary Defense Task Force,

The current risk assessment at the core of the consensus in the Planetary Defense Community seems to have it's origin in the NAC Ad Hoc Task Force on Planetary Defense Final Report. The logic proffered is that since there are more small asteroids than there are large asteroids the next asteroid to strike Earth will likely be small. Therefore we need only prepare for the event of small asteroid impact threat: recommending only a Planetary Defense Coordination Office, a Space based telescope to facilitate Brown and a Demonstration of Concept mission.

By extension, the counter logic would be that since there will always be more small asteroids than there are large asteroids then the next asteroid to strike Earth will always likely be small. However, we understand that sooner-or-later, at random, it will in fact be large. And if we are only prepared to respond to the threat of small asteroid threats then sooner-or-later we will fail... perhaps to the degree of our extinction. This can only be seen as a Hope Based Planetary Defense. Not managing the risk but taking it... Gambling. Optimism. Leaving things to random-chance with an expectation of Good Luck.

- First, we Hope that with the random Scientific Survey approach we will discover the next asteroid on its way to strike Earth.
- Then we Hope that it will be an NEO within the limits of the survey parameters and capabilities.
- Then we Hope that it will have already been perturbed into an Earth impact trajectory before we discover it in order for us to be able to appreciate it as such.
- Then we Hope it will be small in order to accommodate our extemporaneous deflection capability.
- Then we Hope that the Detection-to-Impact Window will be large.
- Then we Hope that there will be a Launch/Transit Window we can execute a response through.
- Then we Hope that our Launch/Transit Window will be early enough to afford a suitable Displacement Window.

- Then we Hope that our Launch/Transit Window will be late enough to afford the time to select, design, develop, build, test, train personnel, and deploy our deflection response.
- Then we Hope that our hasty extemporaneous ad hoc11th Hour mission will not be stalled by political indecision, or delayed in production, or blow up on the launch pad, or fail to achieve heliocentric orbital insertion, or get lost in Space, or miss the target, or not be big enough, or in any otherwise fail to perform as advertised... or Hoped.
- But the greatest Hope of all would be that NASA will still be in business to Hope all these Hopes.

This is little more than a formula for our sooner-or-later suicide by asteroid impact. Hope is not method. We can only ever afford to Hope for the best *after* we have Prepared for the worst. There was good reason and wisdom when the Greeks had Pandora keep Hope in her little box of evil things: Fear.

Comments on NAC Ad Hoc Task Force on Planetary Defense Final Report: 2010
<http://gaiashield.com/NACTaskForceFR/>

following the NASA Authorization Acts of 2005 and 2008, recommended the establishment of a Planetary Defense Coordination Office (https://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp-letter-neoshouse.pdf).

Bad link.
Good link: <https://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp-letter-neos-house.pdf >

This letter, in response to:

H.R. 6063 2008 NASA Authorization Act: SEC. 804. ESTABLISHMENT OF POLICY.
Not later than 2 years after the date of enactment of this Act, the Director of OSTP shall--
(2) **recommend a Federal agency or agencies to be responsible for protecting the Nation from a near-Earth object that is anticipated to collide with Earth** and implementing a deflection campaign, in consultation with international bodies, should one be required.

fails to actually recommend any Federal agency the responsibility for conducting the act of deflecting any asteroids. Instead it recommends NASA take the lead in research and development. Effectively sweeping a National Security problem under the rug of Science.

Then, in 2010:

S. 3729: 2010 NASA Authorization Act: SEC. 808. NEAR-EARTH OBJECT SURVEY AND POLICY WITH RESPECT TO THREATS POSED. (b) IMPLEMENTATION.—The Director of the OSTP shall implement, before September 30, 2012, <SNIP> and assign a Federal agency or agencies to be responsible for protecting the United States and working with the international community on such threats.

And the 2012 deadline came and went and No Joy. No National Planetary Defense Agency was assigned or has been to date. Clearly, such an assignment is far above the pay grade of the Director of OSTP but as an element of the Executive Office it would be at the express will of POTUS... who did sign the 2010 Space Act into law. Making this a failure of the President to comply with his own law.

More recently, similar conclusions were reached in 2014 by an audit of NASA's NEO program by the Office of Inspector General (OIG) (https://oig.nasa.gov/audits/reports/FY14/IG-14-030.pdf).

The only language in the OIG report that could be construed as recommending any Planetary Defense coordination addresses only the pro forma accounting and lawful conduct of NASA's efforts in conducting the Scientific Survey mandated by the Brown Act and those operational elements currently being employed and funded by Congress to conduct a Scientific Survey of the NEO population, and any so far unfunded development of deflection tactics. To date, NASA has no responsibilities to deflect asteroids or in any way protect the Nation from asteroid impact. And the OIG can not make it so.

Such a Planetary Defense Coordination Office would coordinate planetary defense activities across NASA, other U.S. federal agencies, foreign space agencies, and international partners. Establishment of such an office is still needed and is a fundamental component to handling planetary defense matters.

On January 7, 2016: "To improve NASA's efforts to discover, characterize, and catalog NEOs and develop mitigation strategies," NASA has formed a Planetary Defense Coordination Office. However, being only an internal administrative action, in terms of having any degree of formal responsibility for *mitigation*/deflection it falls short of having the legal standing required to appeal to Congress for any discrete funding. And in The Real, you don't get what you don't pay for. The PDCO's budget and intentions are not anywhere close to what would be required to achieve any strategically relevant goals.

Then, consider the mantra of the PDCO and NASA's Asteroid Grand Challenge: "t*o find all asteroid threats to human populations and know what to do about them*". Since it should be clear that any asteroid of any size anywhere in the Solar System could be perturbed into an impending Earth impact threat at any time, to serve this mantra we would need to watch all the asteroids all the time... Forever. Then, knowing '*what to do about them*' is not remotely the same as becoming prepared and capable of doing it. This would be like knowing how to build a fire department but waiting until your house catches on fire before you decide to actually build one. How is this wise?

In light of the failure of the Executive Office to so far comply with its own law, we need to look at this as good soldiers moving to the sound of the guns. The least their Commander in Chief can do now is give them the marching orders they need to secure and develop the resources they need to win this war.

If the test of responsibility is who to blame when bad things happen, this PDCO ain't there yet. If in 10 years a major US city is struck by a 100m asteroid or we go extinct by asteroid impact blame POTUS*. The PDCO is a only a first single step on a journey of a thousand miles. Not the journey complete.

2.5.3. Develop efficient and appropriate responses to the threats posed by NEOs that require cooperation and joint efforts from diverse institutions across national borders.

NEOs are a global threat, and efforts to deal with an impact event may involve at least several nations.

As such, every sovereign nation on the planet is at risk and as such, a stakeholder entitled to a voice in our response. Which can only come with the obligation to fund its pro rata burden of the cost. At the national level, since this can only be seen as a National Security Threat and as such the responsibility of each nation's National security element: Military, funding should be appropriated from these agencies.

The end goal here would be to form a Global Agency of National Agencies. Think NATO not UN. Funded by some portion of each nation's security budget. For the U.S., either way you look at it DoD's JFCC Space (formerly US Space Command) is arguably the largest Space Program on the planet. The first leadership step should be to merge JFCC Space and NASA at the point of their relevant Planetery Defense resources into a hybrid U.S. National Planetary Defense Agency. DoD is also where the U.S. keeps the best of the best of its engineers of method: Expert Risk Managers, Master Strategists and Executive Decision Makers, professionals in dealing with Harm's Way.

Then, since if this agency of agencies is going to be reliably effective it will necessarily employ thermonuclear explosive devices and their delivery systems in any deflection effort. Since the world already spends nearly $100 billion a year to maintain its nuclear weapons arsenal and delivery systems, at least the 1st World Nuclear nations need only retask 50% that budget to Planetary Defense and most of what will be required for a Global allowance to address this threat will be met with no new funding. The cost here can be described as Inverse Opportunity Cost. We loose half our ability to kill each other over economic, political and religious principals and gain the ability to defend ourselves from extinction by asteroid impact: Win/Win! Perhaps we should make that 75%?

The long interval between events warranting response

Delusion. Asteroid impact events are random: without any recursive pattern both in their occasion and magnitude. Therefore we can expect clusters and voids and occasional assorted periodicities not necessarily reflective of any averaged relative frequency. In short, if a 10km asteroid struck Earth yesterday there is no rational reason to think we would not be struck by another 10km asteroid tomorrow. So make that 'The random-chance for long intervals between events warranting response'. *maintaining attention, morale, vigilance, and preparedness for such potentially disastrous events.*

Then, since Fear Defines Necessity, we need an agency that can maintain the global Fear of Death by Rock from Sky and our random extinction by asteroid impact. A well funded private sector strategic think tank and advocacy group would serve best in this role. Although a codified U.S. National Policy to build and maintain the ability to endeavor to deflect these objects as they present themselves to be impending Earth impact threats would be a giant step in the right direction... as well as justify the dedicated funding necessary for maintaining a U.S. National Planetary Defense Agency.

the establishment of the Space Mission Planning Advisory Group (SMPAG) and the International Asteroid Warning Network (IAWN).

Both are only typical UN facades. And until their member nations have codified policies and delegated agencies dedicated to responding to this threat that can fund them, they will remain nothing but ideas.

The primary purpose of the SMPAG is to prepare for an international response to a NEO threat by facilitating exchange of information, encouraging collaborative research and mission opportunities, and providing mitigation planning activities.

But not to actually *do* anything... And as long as we have not unified sovereign nations to be the responsible recipient of their work product their advice will only ever be 'taken under advisement'.

IAWN's purpose is to improve communication between the many actors in the worldwide effort to detect, track, and physically characterize the NEOs.

Which is now the responsibility of NASA's new PDCO. Which funds and directs the facilities generating 98% of all the detecting, tracking, cataloging and characterizing of the NEO population world wide. And which, around 2020 with the completion of the Brown Act, will see its funding cease, and can then turn off the telescopes, declare victory, and go home: World Saved! So, where does the UN think the money will come from to fund IAWN?

increase awareness within the planetary defense and science communities of these entities

Fund them. Awareness will follow. In that direction, what also needs to be addressed is the denial and aversion by scientists and academics for the need to dramatically increase the rational and warranted Fear of potentially manageable Cosmic impact events of any kind. After all, when the day comes to get more money from Congress, scare them better (the unmitigated truth will do). And that day is today. Then, there is the extreme reluctance of this Planetary Defense Community to see this issue evolve into the hands and minds of those better qualified to manage risk, think strategically and shape and inform executive decision making... and deal with Harm's Way as a professional matter of course.

Close:

It has been over 50 years since Gene Shoemaker looked at a fresh bucket of Moon Rocks and declared them to be impact ejecta making us aware of this Cosmic Threat. Since then, at A Million Miles A Day, The Next Large Asteroid on its way to strike Earth has come 20 billion miles closer to impact. And still, after 50 years we do not have a codified National Policy to respond to this threat or delegated a qualified National Planetary Defense Agency to execute such a policy. Tic Toc...

Since it will always include the prospect for our extinction by some random large asteroid impact event, and because we can, knowing which asteroid is the next large asteroid on its way to strike Earth will always be the most important thing Mankind can ever know. And deflecting the next large asteroid on its way to strike Earth will always be be the most important thing Mankind can ever do. And being prepared to effectively respond to the threat of the next large asteroid on its way to strike Earth will always be be the most important thing Mankind can ever be... And WE ARE NOT PREPARED!

If we can not even think about this right how can we expect to ever do this right. The Universe is a dangerous place. It will not suffer dilettantes or fools gladly.

A Million Miles A Day,
R. Dale Brownfield
Gaiashield Group
<http://Gaiashield.Com>
*<http://DearPOTUS.Com>